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Echo Chambers in Parliamentary Twitter Networks: The Catalan Case

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Social media is transforming relations among members of parliaments, but are members taking advantage of these new media to broaden their party and ideological communication environment, or they are mainly communicating with other party members and ideologically aligned peers? This article tests whether parliamentarians' use of Twitter is opening communication flows or confining them to representatives of the same party or ideology. The study is based on a data set spanning the period January 1, 2013, to March 31, 2014, which covers all relations (4,516), retweets (6,045), and mentions (19,507) among Catalan parliamentarians. Our results indicate that communication flows are polarized along party and ideological lines. The degree of polarization of this network depends, however, on where the interactions occur: The relations network is the most polarized; cross-party and cross-ideological interactions are greater in the retweet network and most present in the mention network.

Keywords: polarization, Twitter, parliamentarians, social networks, Catalonia

Democracy is based on the capacity of individuals to freely generate their opinions. To do so, they need to have access to a plurality of information sources (Dahl, 1998), and this access depends very much on the characteristics of their media environments. The increasing popularity and use of social media by parties, politicians, and the public in general has triggered a debate concerning the possibilities of these media to widen the public sphere (Habermas, 1989). Social media might facilitate the flow of ideas, information, attitudes, and opinions—for instance, by enabling direct contact between the public and party representatives (Golbeck, Grimes, & Rogers, 2010; Mackay, 2010; Missingham, 2010)—but they might also polarize politics (Colleoni, Rozza, & Arvidsson, 2014; Esteve Del Valle & Borge, 2017; Garcia, Abisheva, Schweighofer, Serdu, & Schweitzer, 2015; Gruzd & Roy, 2014; Roy, 2012).

The controversy involving political polarization on social media touches a pillar of modern democracy: the necessity of a common public debate where one's ideas and interests are confronted with

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the ideas and interests of those who think differently. Sunstein (2001) claimed that contemporary media and the Internet have abetted a culture of polarization, in which people primarily seek out points of view to which they already subscribe, thereby becoming an echo chamber of already formed political orientations. From that stance, polarization could be explained by the sociological phenomenon called homophily (McPherson, Smith-Lovin, & Cook, 2001), by which interactions occur more often among similar people than among dissimilar people.

Homophily is the basis of the ideological echo chamber effect—that is, the tendency of people to communicate with those who share their political views, thereby creating homogeneous groups. "Homophily limits people's social worlds in a way that has powerful implications for the information they receive, the attitudes they form, and the interactions they experience" (McPherson et al., 2001, p. 415). This is crucial for the well-being of democracy. Exposure to like-minded people is associated with the adoption of extreme positions (Mutz & Martin, 2001) and polarized political stances (Himelboim, McCreery, & Smith, 2013), whereas individuals' network heterogeneity is found to increase their political tolerance and appetite for information on different topics (Scheufele, Hardy, Brossard, Waismel-Manor, & Nisbet, 2006).

This study investigates whether Twitter facilitates the emergence of party and ideological echo chambers in online parliamentary networks. Rather than focusing on ordinary citizens' Twitter political networks, this research aims to understand how social media affect communications among political elites (parliamentarians). The reasoning underlying this choice has to do with the different ways that members of parliament (MPs) and ordinary citizens use Twitter. Whereas MPs' uses of Twitter (in their capacity as politicians) are anchored in considerations of political strategy, the use of Twitter by ordinary citizens is more diverse, including both political and nonpolitical goals.

Twitter is a microblogging social media platform based on not-necessarily reciprocated relationships among users. It offers the possibility to create new information (tweet), spread the information (retweet), and establish dialogic conversations by using the systems of mentions (@) and hashtags (#). Twitter enhances relationship building (Briones, Kuch, Brooke, & Yan, 2011) and offers the potential to deliver conventional forms of discourse to a wider audience (Saebo, 2011) while personalizing communication flows to levels hitherto never reached in politics.

This study contributes to the analysis of political polarization on Twitter by adding a Catalan perspective to previous research in the field (Barberá, Jost, Nagler, Tucker, & Bonneau, 2015; Conover, Ratkiewicz, Francisco, Gonçalves, & Flammini, 2011; Gruzd & Roy, 2014; Hong Sounman & Kim, 2016; Maireder, Schlögl, Schütz, Karwautz, & Waldheim, 2014; Takikawa & Nagayoshi, 2017; Yoon & Park, 2014). It applies social network analyses and statistical techniques to answer the following research question: Does Twitter facilitate Catalan MPs' exposure to cross-party and cross-ideological opinions, or does it confine them to like-minded clusters? We gathered all the Catalan parliamentarians' relations (4,516), retweets (6,045), and mentions (19,507) from January 1, 2013, to March 31, 2014. We chose to study the Catalan case because the rise of the Catalan independence movement foregrounded fragmentation and ideological polarization in the Catalan party system, thereby providing the ideal context to examine cross-ideological and interpartisan interactions. Furthermore, 85% of the Catalan MPs are

Twitter users. To our knowledge, this is the first piece of research to employ a multiplex network approach (Garcia et al., 2015)—that is, the study of different layers of interaction—to study polarization in a European parliamentary Twitter network.

The next section reviews related works on political polarization on Twitter and states the research hypotheses to be tested. We aim to tackle a gap in the research for understanding political polarization in online parliamentary networks in the social media age. We continue by introducing the Catalan case to contextualize the research. We then provide details on the data and the methods. Specifically, we describe the multiplex network approach, which allows us to pinpoint the degree of polarization in the Catalan MPs' Twitter networks in the three different layers of interaction (relations, retweets, and mentions). Last, we outline the results and discuss the study findings, opening new avenues for future research.

Theoretical Background and Hypotheses

Democracies are based on a balance between political homogeneity and polarization. An excess of political homogeneity can render democratic choice meaningless (Sunstein, 2003), whereas too much polarization can create gridlock (Garcia et al., 2015, p. 46). Therefore, it is fundamental to understand how social media make this balance shift to one or the other extreme. Two main lines of research can be identified in the literature concerning political polarization and digital media: (a) studies showing how the Internet facilitates ideological self-segregation and (b) studies showing how the Internet increases exposure to political disagreement.

The first line of research emphasizes that the Internet works as an "echo chamber" in which individuals are exposed to consonant views (Bimber & Davis, 2003). This view is supported by some empirical research such as that conducted by Adamic and Glance (2005) on political blogs. They found two differentiated political communities (liberal or left-wing and conservative or right-wing-leaning blogs) with a strong political correlation with some American newspapers. A similar tendency was found on Facebook by Gilbert and Karahalios (2009), revealing the connection between individuals' political views and the probability that two people are connected on Facebook. Gaines and Mondak (2009) observed that students in a large American university had a marginal tendency to cluster together ideologically on Facebook.

In the political Twittersphere, research also indicates the development and maintenance of ideologically homogeneous clusters. The study of tweets by Feller, Kuhnert, Sprenger, and Wellpe (2011) during the 2009 German federal elections discovered that political tweeters tended to be segregated along lines of shared political affiliation. Hsu and Park's (2012) research on the communication relationships among members of the Korean National Assembly and their constituents showed that intraparty connections were stronger than interparty connections on Twitter. The social network and content analysis by Himelboim et al. (2013) of 10 controversial U.S. political topics on Twitter discovered that "political content, nonetheless, was overall confined to like-minded clusters of users" (p. 171). The analysis by Garcia et al. (2015) of the relations among Swiss politicians on politnetz.ch, a Swiss online platform focused on political activity, found a strongly polarized structure with respect to party alignment. Hong Sounman and Kim's (2016) research on the Twitter activities of the members of the U.S. House of Representatives found evidence of a strong echo chamber communication environment. And Takikawa and

Nagayoshi's (2017, p. 7) study of the Twitter political field in Japan suggested that whether an echo chamber occurs in Twitter depends on the topic of conversation—that is, right-wing followers wrote about Korea, Korean Japanese, and dual nationality issues, whereas left-wing followers wrote about conspiracy law and the corruption of government. The findings of this research about the relationship between echo chambers and political ideologies were consistent with those found by Boutyline and Willer (2017), who discovered that in the U.S. political Twittersphere, both more extreme and more conservative individuals were more likely than liberal and more moderate individuals to form homophilic ties.

Given that the literature suggests that individuals are likely to seek agreement on social media, we expect political homophily to be prevalent in social media. Thus, we propose the following hypothesis:

H1: Communication flows of the Catalan parliamentary Twitter networks (relations, retweets, and mentions) will be polarized along party and ideological lines ("echo chamber hypothesis").

However, not all the literature in this area finds increased political polarization. Research has shown that, even if individuals tend to interact with those who think alike, new media also facilitate cross-ideological contacts with those who think differently. Wojcieszak and Mutz (2009) studied Americans' participation in chat rooms and discovered that exposure to heterogeneous political views happened accidentally and that the potential for deliberation occurred primarily in the groups where politics were not the central purpose of the discussion space. Brundidge (2010) found evidence that through inadvertent exposure, the Internet increased the heterogeneity of political discussion networks, and thus people's exposure to political difference. Gil de Zúñiga and Valenzuela (2011) found that social media facilitated unexpected contacts with weak ties, thereby increasing the likelihood of individuals to be exposed to different political views. And more recently, a study by Dubois and Blank (2018) of the United Kingdom's high-choice media environment found that a greater interest in politics and more media diversity decreases an individual's likelihood of being caught in an echo chamber.

Results from research on Twitter use also show cross-ideological exchanges of political meanings. Colleoni et al.'s (2014) study of the political homophily structure of the complete network of 2009 Twitter users pointed to high levels of homogeneity among them, but it also revealed that the processes of information diffusion in that medium could facilitate individuals' exposure to different political viewpoints. Barberá et al. (2015) discovered that for political issues, information was exchanged among individuals with similar ideological preferences, and for nonpolitical events, ideological homophily in the propagation of the content was low—thus not conforming to the notion of an echo chamber. These findings were corroborated by Vaccari et al. (2016) in their research of German and Italian Twitter users. They found that "social media platforms are not 'echo chambers' of univocal agreement, but 'contrarian clubs' where political disagreement is common" (p. 6).

Most interestingly for the purposes of this research are, perhaps, some findings of previous research that discovered that cross-party and cross-ideological connections on Twitter are dependent on the layers (relations, retweets, and mentions) in which the interactions among users take place. Several studies in different countries reach similar conclusions: The relations and retweet networks are highly polarized, but the mention network shows interconnections among opposed ideologies. Yardi and boyd's

(2010) study of tweets on the shooting of physician George Tiller and conversations among pro-life and pro-choice advocates revealed that "people are more likely to reply to people who share the same view" (p. 13) but that there were also conversations between opposing viewpoints. The analysis by Conover et al. (2011) of political hashtags some weeks before U.S. congressional midterm elections observed that retweets reproduced the known partisan split in the online world, while the mention network indicated that ideologically opposed individuals interacted with one other. Yoon and Park's (2014) study of Korean politicians' use of Twitter revealed that the relations network was a social ritual network (with high reciprocity), whereas the mention network was a network of political support that frequently crossed ideologies. Boutet, Kim, and Yoneki (2012) investigated the use of Twitter during the 2010 UK general election and found that the retweet graph presented a highly segregated partisan structure and that party members were more likely to retweet content from their own party than from other parties. And Gruzd and Roy's (2014) analysis of 5,918 tweets on the 2011 Canadian federal election showed a clustering effect around shared political views among supporters of the same party in the overall communication network of Twitter, but also "evidence of cross-ideological discourse" (p. 38).

In Catalonia, previous research has found that the different layers of interaction seem to perform different functions and that parliamentarians behave strategically in this media environment. New opinion leaders who are not party leaders draw most of the retweets and mentions in the parliamentary Twitter networks (Borge & Esteve Del Valle, 2017a, 2017b).

In sum, given that previous research has shown that political interactions on Twitter are party and ideologically polarized but that the degree of that polarization depends on the layer of interaction (relations, retweets, and mentions) in which the communication flows[1] take place, we propose the following hypothesis:

H2: *The Catalan parliamentary Twitter mention network will reveal more cross-party and cross-ideological connections than will the relations network and the retweet network* ("cross-cutting interactions' hypothesis").

Case Selection

The Catalan parliament was an early adopter of social networking. On March 17, 2009, the parliament launched a project called Parlament 2.0 to "adapt[ing] the Parliament to the new active role of users with social media" (Benach, 2010); to that end, it opened a YouTube channel and Facebook and Twitter profiles. Moreover, in October 2013, the parliament launched Escó 136—a website where Catalan citizenry can leave comments and suggestions regarding projects and laws.[2]

[1] Manuel Castells (2009) defines these flows as "streams of information between nodes circulating through the channels of connection between nodes" (p. 20).

[2] Escó 136 refers to an additional seat in the 135-member parliament. Citizens' comments and suggestions are transferred to the authorities in charge of drawing up Catalan legislation, and they are to be annexed to the law initiative (see Parlament de Catalunya, n.d.).

Catalan representatives also took advantage of these online technologies, as demonstrated by the proportion of Catalan parliamentarians with Twitter profiles in 2014 (85%)—greater than the percentage in the Spanish central parliament (52.6%; Alvarez, 2013), the Spanish senate (33.06%; Alvarez, n.d.), the German Bundestag (31.61%; Thamm & Bleier, 2013), and the UK House of Commons (72.3%; Heaven, 2013), but somewhat behind the U.S. Senate and House of Representatives (100% and 90%, respectively; Sharp, 2013).

During the period when this research was conducted, Catalonia was witnessing an exceptional political context characterized by demands for a referendum on independence as well as widespread protests against austerity measures.[3] In this conflicting political context, social media played a role in political communication and mobilization. Figures compiled by the Centre d'Estudis d'Opinió (2014), a Catalan governmental center for public opinion studies, show notable use among the Catalan citizenry of the Internet (27.8%) and social networks (19.7%) for political purposes.

After the elections of November 25, 2012, the Catalan party system was fragmented into a wide variety of fringe and medium-size parties: CiU, ERC, PSC, PP, ICV-EUiA, C's, and CUP. CiU stands for Convergence and Union, a center-right Catalan nationalist party. It gained 50 seats in the 2012 elections. ERC stands for Republican Left of Catalonia, and it is a left-wing, pro-independence party. It won 21 seats in the elections. PSC is the Socialist Party of Catalonia. In the 2012 elections it gained 20 seats. PP is the People's Party of Catalonia, a right-wing, Spanish nationalist party that won 19 seats. ICV-EUiA is a left-wing party self-defined as eco-socialist, which gained 13 seats. C's stands for Citizens, a centrist and non-Catalan-nationalist party that won nine seats. And CUP stands for Candidacy of Popular Unity; it is an extreme left and pro-independence coalition and won three seats in the 2012 election. Furthermore, the Catalan party system was distributed along two main ideological cleavages: left-wing/right-wing and Catalan nationalist/non-Catalan nationalist (see Figure 1). Consequently, the fragmentation and ideological divisions in the Catalan party system enabled us to carry out in-depth testing of hypotheses related to interaction and communication within and between parliamentary groups.

Last, several studies had shown that social media were contributing to the equalization of opportunities for political communication among Catalan parties, since new, fringe, and medium-size parties as well as parties from various political positions achieve greater online interaction and participation than larger and more institutionalized parties (Balcells & Cardenal, 2013; Borge & Esteve Del Valle, 2017b).

[3] In 2013 there were 6,000 demonstrations in Catalonia, Department of the Interior (see "Es disparen les manifestacions a Catalunya," 2013). According to Centre d'Estudis d'Opinió (2013) figures for June, 45.2% of survey respondents were in favor of Catalan independence (N = 2,000).

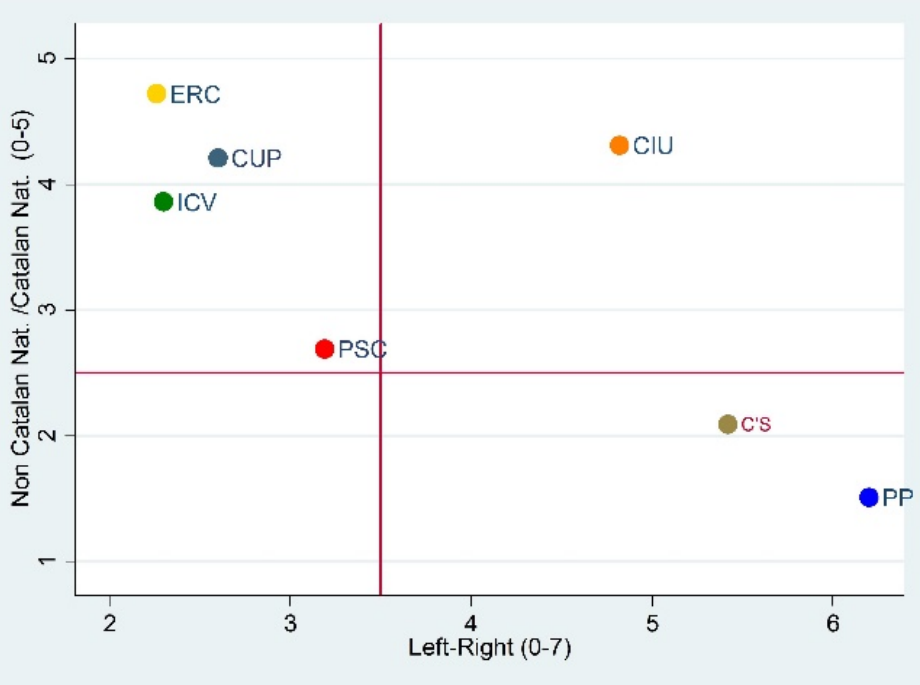

Figure 1. The position of Catalan parties on the political spectrum of Catalonia according to Catalan respondents. Second round of Centre d'Estudis d'Opinió (2013) surveys (N=2,000).

Data

We decided to focus on Twitter because the platform is one of the most popular social media worldwide, 85% of the Catalan MPs are Twitter users, and it is relatively easy to access Twitter data. We scraped the Twitter accounts of the Catalan parliamentarians and retrieved all the relations (4,516), retweets (6,045), and mentions (19,507) from January 1, 2013, to March 31, 2014. These digital traces are analogous to those used in previous works on Twitter for U.S. politicians (Conover et al., 2011), German politicians (Lietz, Wagner, Bleier, & Strohmaier, 2014), and Swiss politicians on politnez.ch (Garcia et al., 2015). By scraping the Twitter accounts of the Catalan MPs, we were able to avoid the restriction on data collection imposed by the Twitter streaming API service, which allows retrieval of a sample (around 1%) of the total amount of tweets posted at any given moment, but the methods that Twitter uses to sample this data are currently unknown (see González-Bailón, Wang, Rivero, & Borge-Holthoefer, 2014; Morstatter, Pfeffer, Liu, & Carley, 2013).

In addition to the Twitter data, we used a representative survey from June 20, 2013, conducted by the Centre d'Estudis d'Opinió to calculate parties' positions on the two axes of the Catalan party system—the left/right axis and the nationalism axis—based on the positions attributed by the interviewees.

Method

We tested the degree of party and ideological polarization in the three layers of interaction (relations, retweets, and mentions) of the Catalan parliamentarians' Twitter network by means of three types of analyses: network visualizations, network polarization, and network topology measurements. We used the open-source software GEPHI to visualize the relations, retweets, and mentions networks of the Catalan MPs. Each node belongs to all layers and represents a parliamentarian with a Twitter account. An MP_1 has a directed link to MP_2 if MP_1 follows MP_2. The retweets and mentions are also directed, but links have weights equivalent to the number of retweets and mentions that MP_1 gave to MP_2. These three layers compose a multiplex network (Menichetti, Remondini, Panzarasa, Mondragón, & Bianconi, 2014). Multiplex networks have one-to-one relationships between nodes across the layers. An example of an analysis of political polarization in multiplex networks is the study of interactions among Swiss politicians on the politnez.ch platform, in which they can support other politicians or like or comment on their posts (Garcia et al., 2015).

To measure party polarization in the three layers of the Catalan parliamentary Twitter network, we used UCINET and calculated the external-internal (E-I) index. This is an index developed by Krackhardt and Stern (1988) as a measure of the group embedding based on comparing the number of ties within groups and between groups. It takes the number of ties of group members to outsiders, subtracts the number of ties to other group members, and divides by the total number of ties. The resulting index ranges from −1 (all ties are internal to the group) to +1 (all ties are external to the group). To assess whether a given E-I index value is significantly different from what would be expected by random mixing (i.e., no preference by group members for ties within or outside the group), a permutation test is performed (the default is 5,000 trials). The range of possible values of the E-I index is restricted by the number of groups, relative group sizes, and the total number of ties in a graph. This is why it is important to rescale the coefficient.

To measure the ideological polarization in the three layers of the parliamentary Twitter network, we computed the Pearson correlation coefficient of the density score of the pairs of parties in the E-I index (1 total possible relations and 0 null relations between the parties) versus the Euclidean distance between pairs of parties in the Catalan two-dimensional ideological space (left/right; Catalan nationalist/non-Catalan nationalist). The logic behind this measure is that the greater the distance between the parties in the ideological spaces, the less likely they will interact on the three layers of the Catalan parliamentary Twitter network.

In addition, we examined other indicators of network polarization that are commonly used to characterize network topology or structure. We suspected that MPs of parliamentary groups with similar network structures and who are closely positioned on the ideological axes will be more likely to interact on Twitter than those with dissimilar structures and who are ideologically opposed (see H1). We chose to analyze the relations network because it best reflects partisan affiliation (Esteve Del Valle & Borge, 2017) and is the most stable over time. Following the work of Garcia et al. (2015), we calculated four network metrics:

- *Party network density* describes the proportion of total connections in a network that are actual connections, ranging from 1 (all ties are connected) to 0 (no ties). By computing this measure, we expect to find the degree of cohesiveness among MPs at a party level.

- *Hierarchical structure* is obtained by calculating the in-degree (the number of followers a parliamentarian's Twitter account holds) centralization as the average difference between the in-degree of the politician with the most followers within the party and the in-degree of all the other politicians. A party with an in-degree centralization of 1 means that one MP is attracting all the followers—that is, representing a network with the strongest hierarchical structure. A party with an in-degree centralization of 0 means that all the MPs have the same number of followers, thereby exhibiting the most egalitarian structure.

- *Information efficiency* is measured in each of the party networks by using the average path length measure. This is a concept in network topology defined as the average number of steps along the shortest paths for all possible pairs of the network nodes. It is a measure of the efficiency of information transport in a network: the shorter the path length, the easier it is to traverse the network and reach other nodes. Thus, the higher the index, the worse the information efficiency.

- *Social resilience* of a network—the ability to withstand external stress—is measured via the k-core: the maximal group of actors, all of whom are connected to a number of other members of the group. We want to find the resilient core of the party networks by estimating their maximum k-core number of MPs. The lower the k-core, the higher the connectivity among the members of the group.

Results

We tested the degree of party and ideological polarization in the three layers of interaction (relations, retweets, and mentions) through visual representation and the measurement of network polarization and network topologies. To visually observe the ideological polarization in the three layers, we created network visualizations of the three parliamentary Twitter networks. Figures 2, 3, and 4 illustrate the network layers of the Catalan parliamentary Twitter network. The nodes are colored according to party affiliation. The size of the nodes is equivalent to their degree in the networks (number of followers, number of retweets received, and number of mentions received, respectively). We used the ForceAtlas2 algorithm layout, which locates connected nodes closer to one another. As shown in the figures, Catalan MPs' communication flows are polarized along party lines in the three layers. However, increased cross-ideological and cross-party connections can be found in the mention network. This is shown, for instance, by the closeness in the graph between the MPs of ERC (a left-wing, Catalan nationalist party) and the MPs of PP and C's (both right-wing, non-Catalan nationalist parties), indicating an intense flow of communication between these ideologically opposed parliamentarians.

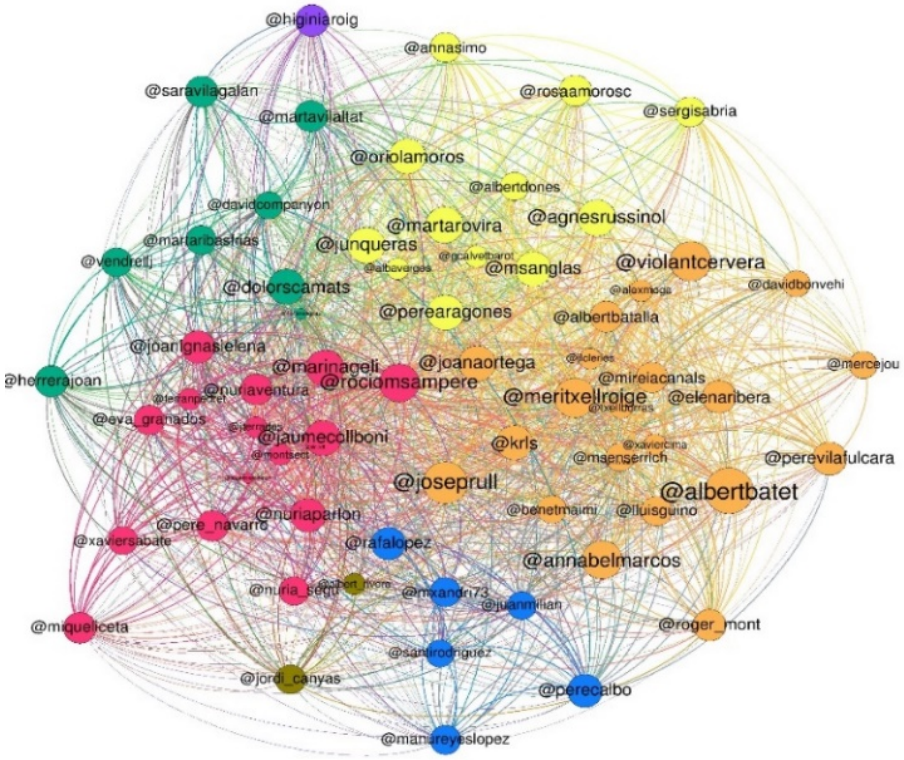

Figure 2. The relations Twitter network of Catalan MPs. For visualization purposes, the nodes of the network are the MPs having between 40 and 75 followers (maximum). The size of the nodes is equivalent to the number of followers in the network. The color of the nodes represents the political party: orange = CIU, yellow = ERC, red = PSC, blue = PP, green = ICV, brown = C's, and violet = CUP.

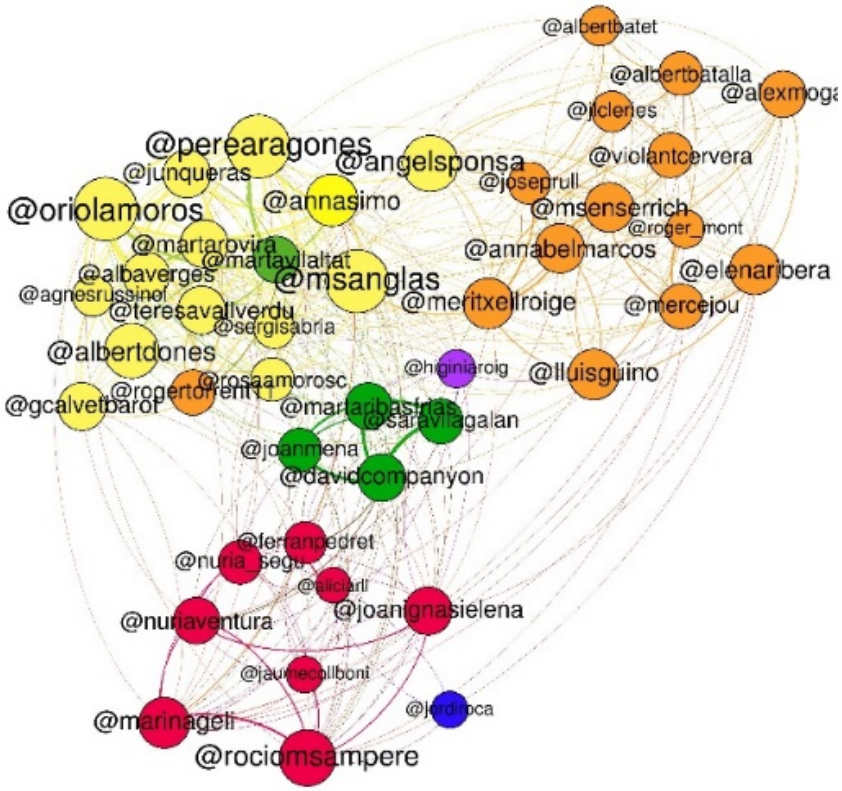

Figure 3. The retweet Twitter network of Catalan MPs. For visualization purposes, the nodes of the network are the MPs having between 40 and 75 followers (maximum). The size of the nodes is equivalent to the number of retweets received in the network. The color of the nodes represents the political party: orange = CIU, yellow = ERC, red = PSC, blue = PP, green = ICV, brown = C's, and violet = CUP.

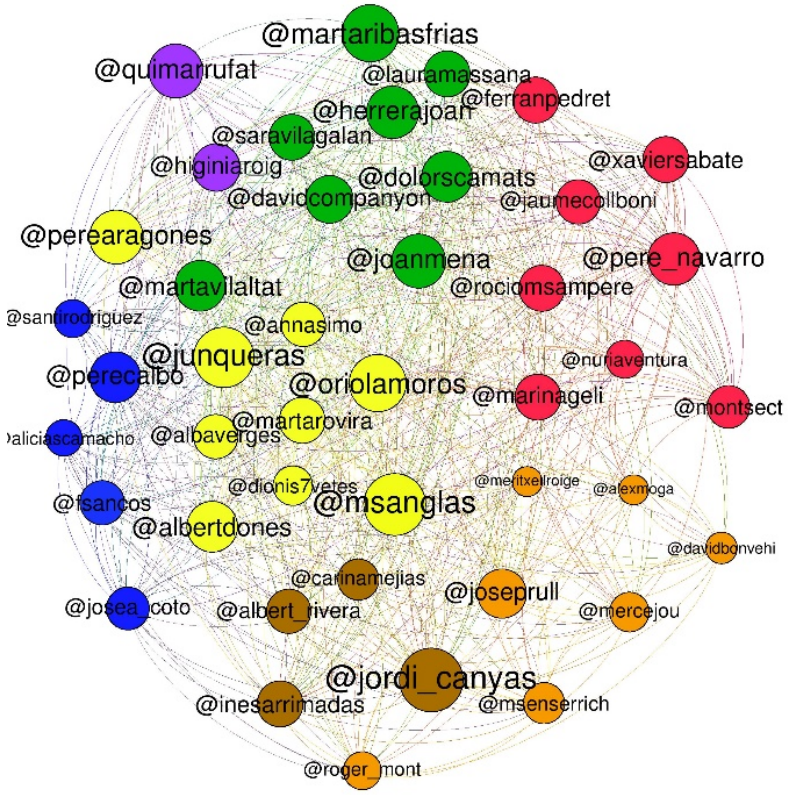

Figure 4. The mentions Twitter network of Catalan MPs. For visualization purposes, the nodes of the network are the MPs having between 40 and 75 followers (maximum). The size of the nodes is equivalent to the number of mentions received in the network. The color of the nodes represents the political party: orange = CIU, yellow = ERC, red = PSC, blue = PP, green = ICV, brown = C's, and violet = CUP.

Analyzing the percentages of total possible interactions of each parliamentary group with itself and with other groups, we find that the percentage of mentions achieved with their own group (66%) is lower than both the percentage of relations with their own group (91%) and the percentage of retweets with their own group (88.5%).

To assess party polarization, we computed the E-I index of each network of interaction. Table 1 shows the results of our analyses.

Table 1. Rescaled E-I Index of the Catalan Parliamentary Twitter Networks.

	Relations network	Retweet network	Mention network
Rescaled E-I index	−0.563	−0.128	−0.082

Note. The E-I index ranges from −1 (all ties are internal to the group) to +1 (all ties are external to the group).

The values of the rescaled E-I index (number of iterations: 5,000)—which takes into account the group sizes of the parties—show that the three layers of the Catalan parliamentary Twitter network are polarized. The degree of polarization, however, varies among the layers: The layer of relations is highly polarized (−0.563); the retweet network (−0.128) is less polarized than the relations network; and the degree of polarization of the mention network is almost null (−0.082).

To measure the ideological polarization in the three layers of the Catalan parliamentary Twitter network, we computed the Pearson correlation coefficient of the pairs of parties in the E-I index versus the Euclidean distance between pairs of parties in the Catalan two-dimensional ideological space (left/right; Catalan nationalist/non-Catalan nationalist). Table 2 shows the results of our analyses.

Table 2. Pearson Correlation Coefficient of the Density of the Pairs of Parties in the E-I Index and Their Pairwise Euclidean Distance.

	Relations network	Retweet network	Mention network
R Pearson	−0.344 (p = .024)	−0.145 (p = .067)	−0.144 (p = .075)

The relations network shows a negative (−0.344) and significant (p = .024) correlation. This indicates a high level of polarization in the relations network and means that the closer the parties are on the ideological axes, the more likely their MPs are to follow one another on Twitter. The retweet network shows a negative (−0.145) but not significant (p = .067) correlation. The mention network also shows a negative (−0.144) but not significant (p = .075) correlation. Consequently, data from the retweet and the mention network are not sufficient to reject the null hypothesis that the two variables are not related, thereby showing that more cross-ideological interactions among parties occur in these networks than in the relations network. However, the negative value of the Pearson correlation in both networks indicates a preference by the parties to communicate with parties in close proximity on the ideological axes.

Last, we analyzed the topology of the relations network of each parliamentary group in the two-dimensional ideological space (left/right; Catalan nationalist/non-Catalan nationalist) by means of four indicators (density, hierarchical structure, information efficiency, social resilience). Figure 5 shows the value of the social network metrics versus the position of each party on both axes.

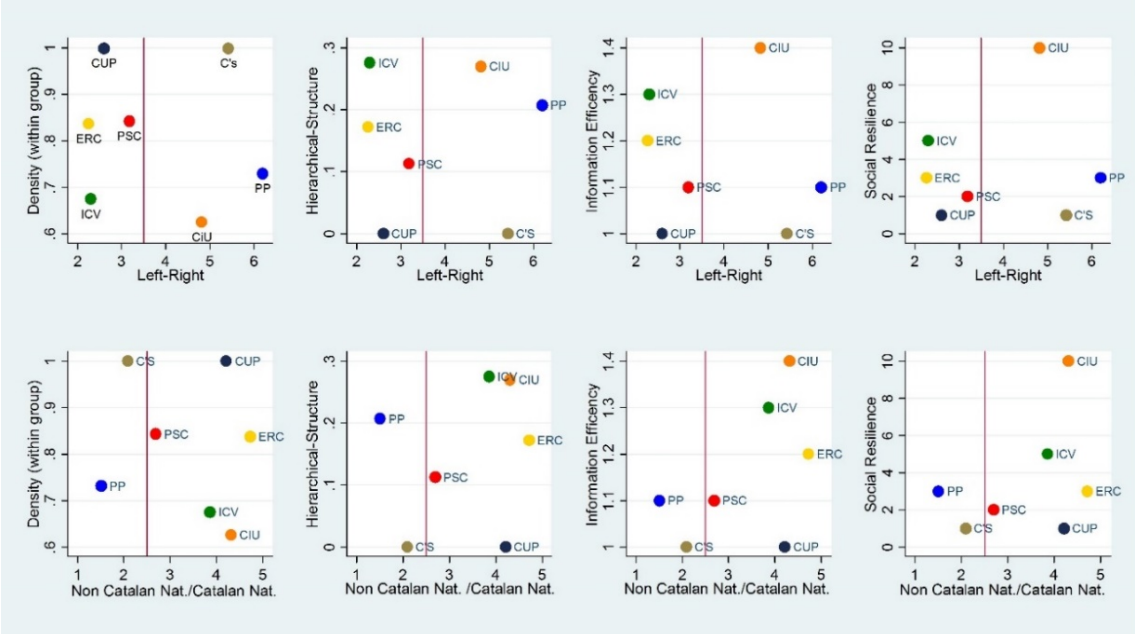

Figure 5. Social network metrics of the Catalan parliamentary groups in the relations network versus their position in the ideological space.

As can be observed, the smallest and least institutionalized parties (C's and CUP) are—independently of their position on the ideological axes—the densest, most egalitarian, most information efficient, and robust against external shocks. These parties, notwithstanding the low frequency of their relations, constitute a specific group, thereby corroborating our previous findings that these two parties behave differently than other Catalan parliamentary groups on social media (Esteve Del Valle & Borge, 2017).

Left-wing parties (ERC and PSC) show higher density and less hierarchical networks than right-wing parties (CiU and PP), and Catalan nationalist parties (CiU, ERC, and ICV) show social network communities with lower information efficiency than non-Catalan nationalist parties (PP and C's). Last, ICV constitutes a fringe case. Although it is a left-wing party, it shows the second lowest density network and the highest hierarchical structure.

Discussion

This research is a first attempt to study polarization in the Catalan parliamentary Twitter network. It contributes to the debate on online polarization by studying this phenomenon in a crucial milieu for the well-being of democracy. We scraped the Twitter accounts of Catalan parliamentarians and retrieved all the relations (4,516), retweets (6,045), and mentions (19,507) among them from January 1, 2013, to March 31, 2014. We chose the Catalan case because the rise of the Catalan independence movement has increased fragmentation and ideological divisions in the Catalan party system, allowing us to test polarization hypotheses among the parliamentary groups. Furthermore, 85% of Catalan MPs are Twitter users.

The study was conducted in the context of an extraordinary moment in the political history of Catalonia. Dealing with the harshest economic crisis since the 1980s, CiU, the ruling party, moved away from its previous position on the independence debate and took a position in favor of a referendum on independence. This strengthened the relevance of the nationalist cleavage over the left/right cleavage and shaped the Catalan political agenda that endures today.

In such a fragmented and ideologically divided party system, our multiplex network analysis of interactions by Catalan MPs on Twitter shows a tendency toward a party and ideological homophily (McPherson et al., 2001), which corroborates the echo chamber hypothesis (H1). Catalan MPs prefer communicating on Twitter with members of their own party and with parliamentarians who are closely positioned on the same political axes (left/right; Catalan nationalist/non-Catalan nationalist). These results are in line with findings of previous research that discovered political tweeters to be polarized around their party affiliation (Feller et al., 2011; Garcia et al., 2015; Hsu & Park, 2012) and ideology (Boutyline & Willer, 2017; Himelboim et al., 2013; Hong Sounman & Kim, 2016). More broadly, they seem to corroborate Sunstein's (2001) claims about the polarization culture triggered by the Internet and contemporary media.

Nevertheless, we also found the degree of polarization of the Catalan parliamentary Twitter network to depend on the layer in which the interactions take place. Similar to previous research in other countries (Conover et al., 2011; Garcia et al., 2015; Gruzd & Roy, 2014), we found that the degree of polarization in the relations network and the retweet network is higher than it is in the mention network (H2), in which the highest number of cross-party and cross-ideological interactions occur among the Catalan MPs who think differently (e.g., between the MPs of ERC and those of PP). Thus, Twitter seems to have a dual nature and be conducive to both the heterogeneous public sphere and the echo chamber scenario (Colleoni et al., 2014): It confines communication flows among party representatives who are ideologically alike, but it also facilitates dialogue among MPs from different parties and ideologies.

Several reasons might explain the different degrees of polarization in the Catalan MPs' Twitter networks. First, the affordances of Twitter networks are conducive to different types of communication—that is, the following-follower network is a relational network, the retweet network is a support network, and the mention network is a dialogical network. Related to this, our study finds that Catalan MPs use the relation and the retweet networks mainly to follow and support the MPs of their party and those who think

alike, whereas they use the mention network to interact with the MPs who think differently. Finally, the intensity of cross-party and cross-ideological interactions between the MPs in the mention network could be explained by the fact that MPs use the affordances of this network to criticize one another. However, this hypothesis exceeds the scope of the present study and should be addressed by an analysis of the mentions' content.

Our research has important implications for understanding whether social media contribute to widening the public sphere in online parliamentary networks. Our findings indicate that Twitter exchanges between Catalan MPs first and foremost take place within their parties or among MPs who think alike. This seems to corroborate the existence of echo chambers and homophilic relations among the Catalan MPs. However, our results also show considerable variation in the degrees of political polarization across the layers of the Catalan parliamentary Twitter network and reveal cross-ideological and cross-party exchanges of meanings among Catalan MPs who think differently. These results align with those found by Karlsen, Steen-Johnsen, Wollebaek, and Enjolras (2017) in their experimental study of online debates, which states that the "Internet provides the opportunity to interact with like-minded people and those with opposite views at the same time" (p. 270), and they seem to corroborate Barbera et al.'s (2015) suspicion that previous studies in the field might have overestimated the degree of political polarization in social media.

Furthermore, we detected that right-wing parties have less dense social networks than left-wing parties and that ICV (a left-wing, green party) has the most hierarchical organization. The results concerning the low density of the right-wing parties are in line with what Garcia et al. (2015) found for Switzerland and contradict those found by Conover et al. (2011) in the United States, which showed that right-leaning users had a higher online social cohesion than left-leaning users. Furthermore, the hierarchical centralization of ICV also resembles the findings of Garcia et al. (2015, p. 62) for Switzerland, where green parties also showed a significantly high in-degree centralization.

Could our research be replicated in other countries or party systems? The object of our study is parliamentarians' communication flows and networks on Twitter, and these are comparable entities across party systems and countries. Consequently, our theoretical framework and the statistical and network analyses used are applicable to all kinds of political contexts. However, future research should undertake a better exploration of three issues that have not been sufficiently studied. First, it is reasonable to complement our analysis of the directions of the communication flows among Catalan parliamentarians with an examination of the content of the information transmitted through Twitter interactions to better ascertain the nature of the polarization and the differences between layers of interaction (Gruzd & Roy, 2014; Takikawa & Nagayoshi, 2017; Yoon & Park, 2014). Second, it seems necessary to carry out more comparative analyses of the parliamentary Twitter networks of different and similar party systems. Considering the political context in every country (Colleoni et al., 2014) would help reach general conclusions about how MPs and parties deal with social media. Last, a longitudinal analysis of Catalan MPs' interactions on Twitter could illuminate differences in party and ideological polarization in the Catalan parliamentary Twitter network.

In conclusion, considering the broader debate on cyberpolitics, this research shows that MPs behave strategically in parliamentary Twitter networks when it comes to using the different layers of communication. Parliamentarians show a clear tendency toward homophily in the relations and retweet networks, but cross-party and cross-ideological connections occur more often in the mention network among those who think differently.

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